An Experimental Study of the Ovipositional Behavior of Opius fletcheri Silvestri (Hymenoptera: Braconidae), a Parasite of the Melon Fly[1]

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Among the parasites of the melon fly, *Dacus cucurbitae* Coquillett, established in Hawaii is *Opius fletcheri* Silvestri, a braconid parasite introduced by D. T. Fullaway from India in 1916. It oviposits in the second and third instar larvae of the melon fly present in the tissues of its host plants. Development takes place within the host larva and, when fully grown, the adult parasite emerges from the puparium of the melon fly (Willard, 1920).

The melon fly has a wide host range and the extent of parasitization of the larvae by *O. fletcheri* has been observed to vary with the kind of plant in which the host larvae are present. Field data of Willard (1920) show that the percentage of parasitization was lower among larvae infesting cucumber fruits than those infesting the wild balsam apple, *Momordica balsamina* L. Recent field observations made on a wide variety of host plants also showed that the parasitization of larvae infesting cultivated plants was consistently lower than those infesting the wild balsam apple (Nishida, 1955). These observations also showed that, although the incidence of parasitization was generally low, there was a definite indication that the larvae in the vines of certain plants, such as pumpkin and watermelon, were parasitized to a greater extent than those in the fruit.

In view of these observations, investigations were made to determine some of the underlying causes of the variation in parasitization of melon fly larvae infesting various plants by *O. fletcheri*. The present paper is concerned primarily with the oviposition behavior of *O. fletcheri* as influenced by the kind of medium in which its host larvae are present.

Method

The oviposition behavior of *O. fletcheri* was observed in cages made of a gallon size glass jar with a screw cap cover (fig. 1A). This type of cage, which

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is similar to those used by other investigators, is constructed by cutting off the bottom of the jar and covering the opening thus formed with thin organdie, of approximately 50 meshes per linear inch (fig. 1E). A circular opening was cut out in the screw cap cover, and the opening thus formed was covered with a 32 mesh per linear inch plastic screen (fig. 1D). Five females were kept in each cage. They were fed on honey by smearing small quantities of honey on a strip of celluloid. A vial containing absorbent cotton saturated with water was also placed in each cage (fig. 1C, 1G).

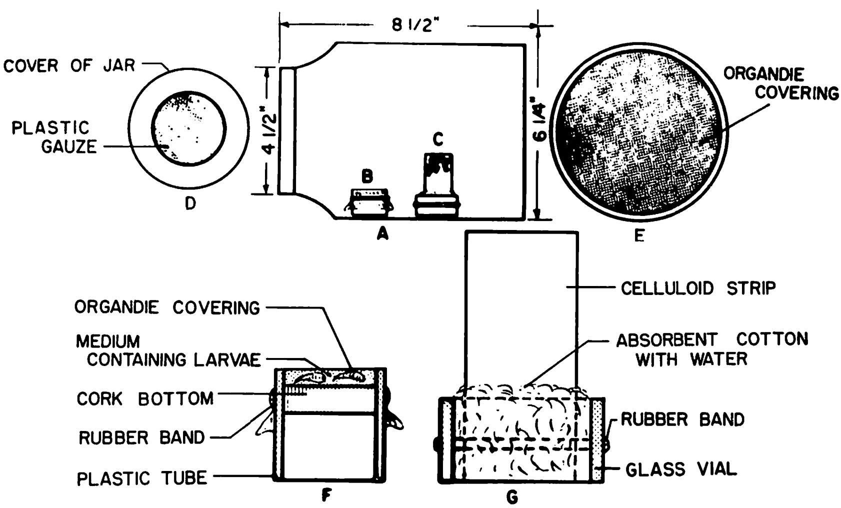

FIG. 1. Showing parasite cage and larval container used in this study. A. Glass jar with vial B containing melon fly larvae and vial C containing absorbent cotton saturated with water and a strip of celluloid on which honey is placed. D. End view of the cage showing plastic gauze in place. E. End view of cage showing the organdie covering. F. Detail sectional view of vial B. G. Detail sectional view of vial C.

The type of container used in confining melon fly larvae when exposing them to the parasites was a vial with a movable bottom which permitted the adjustment of the depth of the vial (fig. 1B, 1F). This vial, which restricted the movement of the larvae to a prescribed depth, was constructed from a plastic tubing with an internal diameter of one inch. The tubing was first cut into one inch segments and a tight-fitting cork approximately ¼ inch in thickness was inserted into each segment. This cork, which formed the bottom of the vial, was movable and, hence, the depth of the vial could be adjusted to any desired depth. In these studies the depth was adjusted to 3 mm.

The plant tissues used as media for exposing melon fly larvae to *O. fletcheri* were first chopped with a knife into small pieces. The pieces were then chopped fine by means of a Waring blendor with sufficient water added to facilitate the action of the blendor. After about 30 seconds of grinding, the finely chopped plant tissue was emptied on a sheet of muslin and excess water squeezed out.

In exposing melon fly larvae to parasitization, a small amount of the finely ground plant tissue was first placed in the plastic vial and 15 to 25 fully grown larvae were placed in each vial. The top of the vial was then covered with a sheet of thin organdie which was held tightly stretched by means of a rubber band (fig. 1F). To determine the per cent parasitization one vial was placed in each cage containing five females. After one hour the larvae were removed from the vial and placed on sand in rearing jars described by Newell *et al* (1951). Upon emergence counts were made of the number of adult parasites and flies.

THE INFLUENCE OF HOST MEDIA ON ATTRACTION

Before egg deposition within the host larvae can occur, the female parasite must locate its host. The role of the larval media in enabling the female to locate its host was investigated.

Attraction of O. fletcheri to media

Experimental studies were carried out to determine whether the medium in which the melon fly larvae are present or the larvae themselves attracted the female of *O. fletcheri* to its host larvae. Vials with ground leaf tissues and those with stem tissues each containing 25 fully grown larvae were placed singly in cages each containing five gravid females of *O. fletcheri*. In addition vials containing ground leaf tissues and also stem tissues without larvae were placed in separate cages. Vials which contained 25 larvae without any medium were also placed in similar cages. The attraction of the respective vials to the females was then determined by counting the number of female parasites on the vials at 5, 10, 15, 20, 25, 30, 40, and 60 minutes after placing the vials in the respective cages. The counts which represent a mean of five replicates are shown in table 1.

The results show that (1) the female parasites were attracted to the vials containing the media regardless of whether or not the host larvae were present and (2) the female parasites were not attracted to vials which contained only larvae. The number of females observed on vials with media and larvae, and those with media alone was approximately the same soon after the vials were placed in the cages; however, subsequently there was a general decrease with time. This decrease occurred because when host larvae were present the females remained on the vials for long periods walking over the vials, stopping periodically to oviposit. However, in the absence of larvae the females walked over the vials for a short time making no attempts to oviposit. These observations show that the gravid females are attracted not to the host larvae, but to the media in which the host larvae are present.

A similar experiment was performed in order to determine whether females of all ages behaved in the same manner as the gravid individuals. Three newly emerged males and five newly emerged females were placed in a series of cages. From the day of emergence up to the time the parasites were 22 days old, separate vials containing watermelon and pumpkin vine media, each with 15 larvae, were placed in the respective cages. The number of females on the respective vials was counted as in the previous experiment.

The results of this study show that females younger than three days were not attracted to the media. Females began to be attracted to the media when 4 to 5 days old, and thereafter the number of parasites counted in the respective vials remained nearly constant for 22 days. Because the preoviposition period of *O. fletcheri* is about 3 days it appears that egg development and attraction to media are closely associated.

TABLE 1. The attraction of gravid *O. fletcheri* to vials containing medium alone, medium and host larvae, and host larvae alone.

TIME AFTER PLACING VIALS IN CAGES (minutes)	MEAN NUMBER OF PARASITES OBSERVED ON VIALS CONTAINING				
	Pumpkin leaf		Pumpkin stem		Larvae alone
	With larvae	Without larvae	With larvae	Without larvae	
5	3.0	3.8	2.8	2.2	0
10	4.2	2.8	3.2	1.8	0
15	3.8	2.2	3.4	1.2	0
20	3.0	1.8	1.6	1.0	0
25	3.6	1.8	1.8	0.6	0
40	3.0	1.0	1.4	0.4	0
50	2.8	1.2	0.8	0.4	0
60	1.6	1.0	1.4	0.4	0

Similar experiments were also carried out to determine whether the males behaved in the same manner as the females. There was no evidence that the males were attracted to the media.

Variation in attractiveness of different media

The relative attractiveness of various media to gravid females was determined by placing a known number of females in cages and placing vials containing various media with melon fly larvae in the cages. Five gravid parasites per cage and 25 larvae per vial containing different media were used. At 5, 10, 15, 20, 30, 40, and 60 minutes after placing the vials in the cages, counts were made of the number of individuals present on the respective vials. The total number of females observed per vial is referred to as the index of attraction. The mean indices obtained from five observations are summarized in fig. 2.

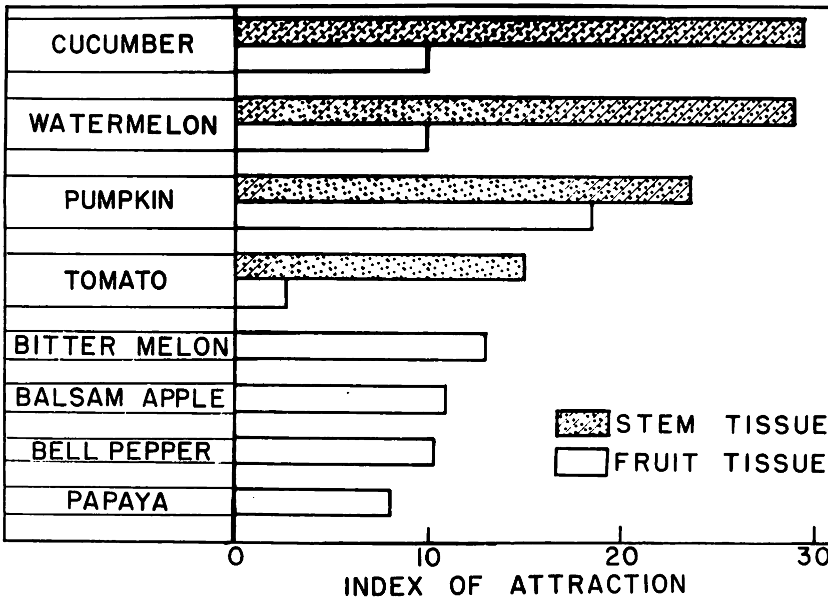

FIG. 2. Variation in the index of attraction of various plants as well as that of fruit and stem tissues. The plants listed are cucumber, *Cucumis sativus;* watermelon, *Citrullus vulgaris;* pumpkin, *Cucurbita pepo;* tomato, *Lycopersicon esculentum;* bitter melon, *Momordica charantia;* balsam apple, *Momordica balsamina;* bell pepper, *Capsicum frutescens* var. *grossum*; and papaya, *Carica papaya.*

The result shows that there is a considerable variation in the index of attraction of different media. Of particular interest is the greater attractiveness of the stem over fruit tissues of the plant. The greater attractiveness of stem over fruit tissue is evident even in the case of the tomato plant, the stem of which is not attacked by the melon fly. Among fruit tissues, the medium consisting of ground tomato fruit was the least attractive.

THE INFLUENCE OF HOST MEDIA ON OVIPOSITION

Stimulus to oviposition

When a female of *O. fletcheri* comes in contact with a suitable medium, she walks over the surface, stopping periodically, apparently in search of the host larvae. When she comes to a spot where there is a larva in the medium, she raises the abdomen and inserts the ovipositor through the medium and into the body of the larva. In vials containing a suitable medium but without larvae, the parasite made no attempt to insert the ovipositor into the medium. Oviposition, therefore, appears to be stimulated not by the medium, but by the host larva.

An experiment was carried out to determine whether larvae of other Diptera would stimulate oviposition when present in a suitable medium. The larvae of the melon fly, *Dacus cucurbitae* Coquillet; oriental fruit fly, *D. dorsalis* Hendel; housefly, *Musca domestica* L.; and scavenger fly, *Atherigona excisa* (Thomson), were placed in separate vials containing various media. Vials containing these various larvae were then placed individually in cages each containing five gravid females of *O. fletcheri*. In addition, vials containing larvae without medium were placed in similar cages. Observations were made on oviposition for one hour and each larva was dissected to determine whether or not oviposition had taken place.

This experiment showed that gravid females were attracted to all of the vials containing media, regardless of the species of larva present in the medium. However, the act of oviposition was observed only among females present on vials containing the larvae of the melon fly, oriental fruit fly, and the housefly. The parasites made no attempt to oviposit in the larvae of the scavenger fly which, incidentally, is considerably smaller than those of the other species. Dissection of the larvae showed that actual egg deposition occurred only in the larvae of the melon and the oriental fruit flies (table 2). This experiment also showed that *O. fletcheri* is not attracted to vials without any medium and, hence, there was no egg deposition in larvae in such vials.

TABLE 2. Egg deposition by *Opius fletcheri* in the larvae of four species of flies when placed in media attractive to the parasite. Egg deposition was determined by dissection.

SPECIES OF LARVAE EXPOSED	NUMBER OF REPLICATES	TOTAL NO. OF LARVAE	PER CENT PARASITIZED IN THE INDICATED MEDIA			
			Pumpkin vine	Watermelon vine	Cucumber vine	Without medium
Melon fly (*Dacus cucurbitae*)	3	30	76.0	60.0	83.3	0
Oriental fruit fly (*Dacus dorsalis*)...	3	30	90.0	53.3	83.3	0
Scavenger fly (*Atherigona excisa*)	3	30	0	0	0	0
Housefly (*Musca domestica*).	3	30	0	0	0	0

Furthermore, these observations show that the medium does not stimulate the act of oviposition. Oviposition appears to be stimulated by the larvae within the host medium. These observations also indicate that the larvae of certain species stimulate oviposition while others do not. Lathrop and Newton (1933) reported that the stimulus to oviposition of *Opius melleus* Gahan, a parasite of the blueberry maggot, is the vibration produced by the movements of the host larvae within the plant tissue. They induced the act of oviposition of *O. melleus* by making simulated larval movements under the skin of the blueberry by means of a needle or a pair of forceps. If such vibrations stimulate oviposition, then there must be differences in the characteristics of vibrations produced between larvae of species that do stimulate oviposition and those that do not.

The data obtained in the present study also indicate that, although the larvae of the housefly are capable of stimulating the act of oviposition, egg deposition does not take place, possibly because of certain unfavorable characteristics of the integument.

Relationship between the index of attraction and parasitization

A scatter diagram depicting the relationship between the index of attraction of various media and per cent parasitized larvae in the respective media is shown in fig. 3. With the exception of the tomato fruit medium, which had a low index of attraction and a corresponding low parasitization, all media prepared from fruit tissues were attractive enough to result in parasitization to an extent of 40 to 76 per cent under the conditions of the experiment. Media prepared from stem tissues were highly attractive; however, the percentage parasitization did not increase proportionately. Because of this deceleration the relationship between the index of attraction and parasitization

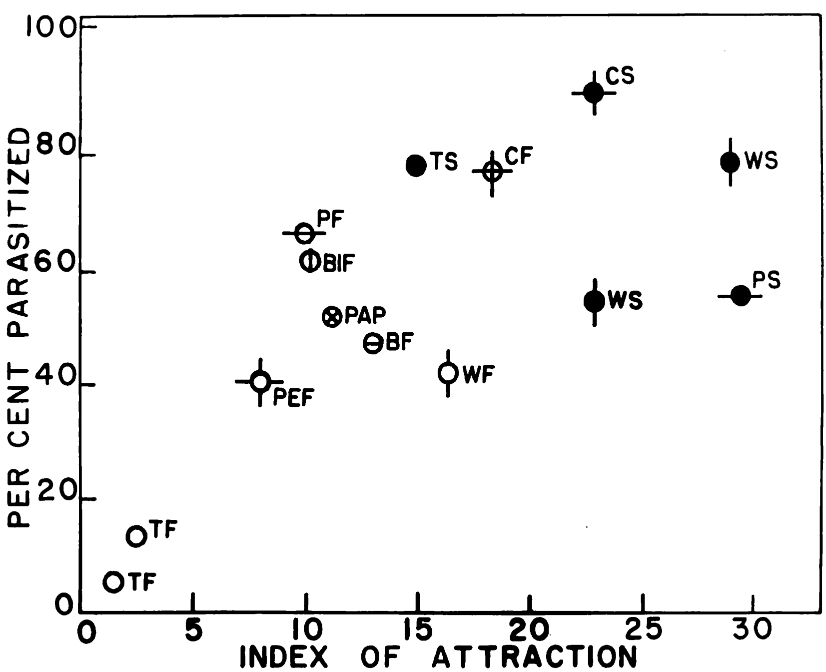

FIG. 3. Scatter diagram depicting the relationship between attraction to various media and percent parasitization by *Opius fletcheri.* The symbols used are TF, tomato fruit; TS, tomato stem; CF, cucumber fruit; CS, cucumber stem; PF, pumpkin fruit; PS, pumpkin stem; WF, watermelon fruit; WS, watermelon stem; PAP, papaya fruit; BF, balsam apple fruit; BIF, bitter melon fruit; and PEF, pepper fruit. For scientific names of these plants refer to figure 2.

tends to be non-linear. This type of relationship, which has been observed by various workers dealing with host-parasite density relationships, might be related to superparasitism and interference among females which results when too many individuals are attracted to a particular medium.

Discussion

Although the factors which determine whether or not a potential host species would be parasitized by a given parasite are complex, it is clear that the habitat of the susceptible stage of the host insect is an important factor. The importance of the habitat has been pointed out by Salt (1938) when he outlined the processes of host elimination by a given parasite. "Host habitat finding," according to Salt, is the first step in host elimination and is the one in which a majority of the potential host species are eliminated from the host list of a given parasite. This behavior of habitat finding, first reported by Picard and Rabaud in 1914, has been reported subsequently by others, among whom may be mentioned Gahan (1933), Thorpe and Jones (1937), Laing (1937), and Flanders (1940, 1953). The current study shows that *O. fletcheri* also behaves in a similar manner as that of other parasites reported in the literature. The medium in which the melon fly larvae are present is considered to be the host habitat in the present study, even though the term "host microhabitat" may be a more appropriate one.

The melon fly has a wide host range, infesting at least 36 species of plants in 12 botanical families (McBride and Tanada, 1947). Although many of these plants were not studied, it is conceivable that some would be unattractive to *O. fletcheri* and, hence, melon fly larvae infesting such plants would escape being attacked to a greater extent than those infesting attractive plants.

To determine the cause of the differences in attractiveness among media prepared from different plants or from different parts of the same plant was not within the scope of the present study. These differences are no doubt related to differences in the chemical composition, for Thorpe and Caudle (1938) have shown that certain substances present in plant tissues attract only the gravid females of *Pimpla ruficollis* Gravenhorst, a hymenopterous parasite of the pine shoot moth, *Rhyacionia* (*Evetria*) *buoliana* Schiffermüller.

It appears that attractiveness alone can not account in all cases for the differences in parasitization of larvae present in various plants observed in the field because there was a wide discrepancy between field and laboratory data. Evidently under field conditions, there are, besides attractiveness, other host elimination factors in operation about which nothing is known. In the case of the parasitization of larvae in watermelons, however, attractiveness appears to be a factor worthy of consideration. Data pertaining to the higher parasitization of larvae in the stem tissues than those in the fruit were obtained (Nishida, 1955). In the interpretation of the data it was pointed out that such differences were due to the differences in the depth at which the larvae were present. On the basis of the present study, which showed the greater attractiveness of stem over fruit tissues, it is clear that in addition to depth, attractiveness is a factor to be considered in the interpretation of field data such as those mentioned above.

Summary

The present paper deals with an experimental study on the oviposition behavior of *Opius fletcheri* Silv., a parasite of the melon fly, *Dacus cucurbitae* Coq., established in Hawaii. It was shown that *O. fletcheri* is attracted to its host larvae by the host plant tissue rather than the larvae *per se*. Medium prepared from the tomato fruit was not attractive to the gravid females, but media prepared from other fruits such as watermelon, cucumber, papaya, pepper, and *Momordica* spp. were moderately attractive. Attraction was highest among media prepared from the stem of tomato, cucumber, watermelon, and pumpkin. Although the medium was responsible for the attraction of the parasite to the host larva, it played no role in stimulating oviposition. Oviposition was found to be stimulated by the larvae rather than the medium. In general parasitization was correlated, though not linearly, with the attractiveness of the respective medium. It was concluded that differences in the attractiveness of the media are not adequate to account for the variation in parasitization observed among larvae infesting various plants in the field.

References

FLANDERS, S. E. 1940. Environmental resistance to the establishment of parasitic Hymenoptera. ANN. ENT. SOC. AMER. 33:245–253.

——— 1953. Variations in susceptibility of citrus-infesting coccids to parasitization. JOUR. ECON. ENT. 46(2):266–269.

GAHAN, A. B. 1933. The serphoid and chalcidoid parasites of the Hessian fly. U.S. DEPT. AGR. MISC. PUB. 174.

LAING, J. 1937. Host finding by insect parasites. JOUR. ANIM. ECOL. 6:298–317.

LATHROP, G. H. and R. C. NEWTON. 1933. The biology of Opius melleus Gahan, a parasite of the blueberry maggot. JOUR. AGR. RES. 46:143–160.

MCBRIDE, O. C. and Y. TANADA. 1947. A revised list of host plants of the melon fly in Hawaii. PROC. HAW. ENT. SOC. 13:411–421.

NEWELL, I. M., R. VAN DEN BOSCH, and F. HARAMOTO. 1951. An improved method of rearing field collected fruit fly larvae. PROC. HAW. ENT. SOC. 14(2):277–299.

NISHIDA, T. 1955. Natural enemies of the melon fly, Dacus cucurbitae Coq., in Hawaii. ANN. ENT. SOC. AMER. 48(3):171–178.

PICARD, F. and E. RABAUD. 1914. Sur le parasitisme externe des braconides (Hym.). BULL. SOC. ENT. FRANCE pp. 266–269.

SALT, G. 1938. Experimental studies in insect parasitism. VI. Host suitability. BULL. ENT. RES. 29:223–246.

THORPE, W. H. and H. B. CAUDLE. 1938. A study of the olfactory responses of insect parasites to the food plant of their host. PARASITOLOGY 30(4):523–528.

——— and F. G. W. JONES. 1937. Olfactory conditioning in a parasitic insect and its relation to the problem of host selection. PROC. ROY. SOC. (B) 124:46–81.

WILLARD, H. F. 1920. Opius fletcheri as a parasite of the melon fly in Hawaii. JOUR. AGR. RES. 20(6):423–438.